CLAIMS

[1] A lens driving apparatus, comprising:

an imaging lens including a focus adjustment lens that forms an image of a subject;

an imaging device that images light of the subject by way of the imaging lens;

a lens position controller including a driver that shifts the imaging lens in a direction of an optical axis with respect to a lens barrel, the lens position controller outputting a periodic driving signal and controlling a position of the imaging lens using the driver;

a position detection sensor whose output value varies with a position of the imaging lens;

a lens position calculator that determines a phase of the driving signal as a reference position of the imaging lens when the output value of the position detection sensor reaches a threshold value; and

a reference position storage that stores the reference position,

wherein the lens position calculator

determines a position obtained by performing addition or subtraction on the reference position read out from the reference position storage as a judgment position,

detects an output value of the position detection sensor at a timing in synchronization with the driving signal that drives the driver and at the judgment position, and

judges whether the output value of the position detection sensor at the judgment position reaches the threshold value or not, so as to determine the reference position again.

[2] The lens driving apparatus according to claim 1, wherein the driving signal that drives the driver for determining the reference position is a substantially sine wave signal.

[3] The lens driving apparatus according to claim 1,

wherein assuming that a time of one cycle of the driving signal that drives the driver for determining the reference position is T, a driving signal that drives the driver for determining the reference position again is a M/N periodic driving signal whose one cycle is (M/N)·T, where N=2n (n is an integer of 2 or more) and M is an integer satisfying 2n>M>2.

[4] The lens driving apparatus according to claim 1, wherein the judgment position is located at a position 1/2 cycle of the driving signal away from the reference position read out from the reference position storage.

[5] The lens driving apparatus according to claim 3, wherein the judgment position is located at a position 1/2 cycle of the M/N periodic driving signal away from the reference position read out from the reference position storage.

[6] The lens driving apparatus according to claim 1,

wherein the lens position calculator designates the judgment position as a stopping position, and

the lens position controller shifts the imaging lens to the stopping position before turning a power supply of the lens driving apparatus off.

[7] The lens driving apparatus according to claim 1,

wherein the lens position calculator determines as a stopping position a position obtained by performing addition or subtraction on the reference position,

the lens controller shifts the imaging lens to the stopping position before turning a power supply of the lens driving apparatus off, and

the stopping position is a position 1/2 cycle of the driving signal away

from the reference position.

[8] The lens driving apparatus according to claim 3,

wherein the lens position calculator determines as a stopping position a position obtained by performing addition or subtraction on the reference position,

the lens controller shifts the imaging lens to the stopping position before turning a power supply of the lens driving apparatus off, and

the stopping position is a position 1/2 cycle of the M/N periodic driving signal away from the reference position.

[9] The lens driving apparatus according to claim 1, further comprising an angular sensor that detects an inclination angle of the lens barrel,

wherein the lens position calculator determines, based on inclination angle information of the lens barrel output from the angular sensor, a correction distance corresponding to a displacement from a reference angle, and

the lens position calculator

designates a position obtained by performing addition or subtraction of the correction distance with respect to the judgment position as a new judgment position, and

designates the new judgment position as the position where the output value of the position detection sensor is detected for the judgment.

[10] The lens driving apparatus according to claim 1, further comprising an angular sensor that detects an inclination angle of the lens barrel,

wherein the lens position controller controls a position of the imaging lens based on correction position information that is based on information of the reference position and inclination angle information of the lens barrel output from the angular sensor.

[11] The lens driving apparatus according to claim 1,

wherein the lens position calculator

determines as an upper end position of the imaging lens a phase of the driving signal when the output value of the position detection sensor reaches a threshold value in a state of the lens barrel facing upward,

determines as a lower end position of the imaging lens a phase of the driving signal when the output value of the position detection sensor reaches a threshold value in a state of the lens barrel facing downward, and

calculates the reference position based on the upper end position and the lower end position.

[12] The lens driving apparatus according to claim 10, wherein the lens position calculator calculates an intermediate position between the upper end position and the lower end position as the reference position.

[13] The lens driving apparatus according to claim 1,

wherein the lens position calculator determines as an upper or a lower end position of the imaging lens a phase of the driving signal when the output value of the position detection sensor reaches a threshold value in a state of the lens barrel facing upward or downward, and calculates the reference position by performing addition or subtraction of a predetermined distance with respect to the upper or the lower end position.

[14] The lens driving apparatus according to claim 1, further comprising a temperature sensor that detects a temperature of the lens barrel,

wherein the lens position calculator determines, based on temperature information of the lens barrel output from the temperature sensor, a correction distance corresponding to a displacement from a reference temperature, and

the lens position calculator

designates a position obtained by performing addition or subtraction of the correction distance with respect to the judgment position as a new judgment position, and

designates the new judgment position as the position where the output value of the position detection sensor is detected for the judgment.

[15] The lens driving apparatus according to claim 1, further comprising a temperature sensor that detects a temperature of the lens barrel,

wherein the lens position controller controls a position of the imaging lens based on correction position information that is based on information of the reference position and temperature information of the lens barrel output from the temperature sensor.

[16] The lens driving apparatus according to claim 1, further comprising an angular sensor that detects an inclination angle of the lens barrel and a temperature sensor that detects a temperature of the lens barrel,

wherein the lens position calculator determines, based on inclination angle information of the lens barrel output from the angular sensor, an angle correction distance corresponding to a displacement from a reference angle, and determines, based on temperature information of the lens barrel output from the temperature sensor, a temperature correction distance corresponding to a displacement from a reference temperature, and

the lens position calculator

designates a position obtained by performing addition or subtraction of a total distance of the angle correction distance and the temperature correction distance with respect to the judgment position as a new judgment position, and

designates the new judgment position as the position where the output value of the position detection sensor is detected for the judgment.

[17] A lens driving apparatus, comprising:

an imaging lens including a focus adjustment lens that forms an image of a subject;

an imaging device that images light of the subject by way of the imaging lens;

a lens position controller including a driver that shifts the imaging lens in a direction of an optical axis with respect to a lens barrel, the lens position controller outputting a periodic driving signal and controlling a position of the imaging lens using the driver;

a position detection sensor whose output value varies with a position of the imaging lens;

a lens position calculator that determines a phase of the driving signal as a reference position of the imaging lens when the output value of the position detection sensor reaches a first threshold value; and

a reference position storage that stores the reference position,

wherein the lens position calculator

designates as a judgment position a position having a same phase as a phase of the reference position read out from the reference position storage,

detects an output value of the position detection sensor at a timing in synchronization with the driving signal that drives the driver and at the judgment position, and

judges whether the output value of the position detection sensor at the judgment position reaches a second threshold value different from the first threshold value or not, so as to determine the reference position again.

[18] The lens driving apparatus according to claim 17,

wherein assuming that a time of one cycle of the driving signal that drives the driver for determining the reference position is T, a driving signal that drives the driver for determining the reference position again is a 1/N

periodic driving signal whose one cycle is T/N (N is an integer of 2 or more).

[19] The lens driving apparatus according to claim 17, wherein the second threshold value is a value within a range of an output value of the position detection sensor between the reference position and a position one cycle of the driving signal away from the reference position.

[20] The lens driving apparatus according to claim 17, wherein the second threshold value is an output value of the position detection sensor at a position 1/2 cycle of the driving signal away from the reference position.

[21] The lens driving apparatus according to claim 17,

wherein the lens position calculator designates the judgment position as a stopping position, and

the lens position controller shifts the imaging lens to the stopping position before turning a power supply of the lens driving apparatus off.

[22] The lens driving apparatus according to claim 17,

wherein the lens position calculator designates as a stopping position a judgment position that is an immediately preceding of a judgment position corresponding to the reference position determined again, and

the lens position controller shifts the imaging lens to the stopping position before turning a power supply of the lens driving apparatus off.

[23] The lens driving apparatus according to claim 17, further comprising an angular sensor that detects an inclination angle of the lens barrel,

wherein the lens position calculator determines, based on inclination angle information of the lens barrel output from the angular sensor, a correction distance corresponding to a displacement from a reference angle, and

the lens position calculator

designates a position obtained by performing addition or subtraction of the correction distance with respect to the judgment position as a new judgment position, and

designates the new judgment position as the position where the output value of the position detection sensor is detected for the judgment.

[24] The lens driving apparatus according to claim 17, further comprising an angular sensor that detects an inclination angle of the lens barrel,

wherein the lens position controller controls a position of the imaging lens based on correction position information that is based on information of the reference position and inclination angle information of the lens barrel output from the angular sensor.

[25] The lens driving apparatus according to claim 17,

wherein the lens position calculator

determines as an upper end position of the imaging lens a phase of the driving signal when the output value of the position detection sensor reaches the first threshold value in a state of the lens barrel facing upward,

determines as a lower end position of the imaging lens a phase of the driving signal when the output value of the position detection sensor reaches a threshold value in a state of the lens barrel facing downward,

and calculates the reference position based on the upper end position and the lower end position.

[26] The lens driving apparatus according to claim 25, wherein the lens position calculator calculates an intermediate position between the upper end position and the lower end position as the reference position.

[27] The lens driving apparatus according to claim 17,

wherein the lens position calculator determines as an upper or a lower end position of the imaging lens a phase of the driving signal when the output value of the position detection sensor reaches the first threshold value in a state of the lens barrel facing upward or downward, and calculates the reference position by performing addition or subtraction of a predetermined distance with respect to the upper or the lower end position.

[28] The lens driving apparatus according to claim 17, further comprising a temperature sensor that detects a temperature of the lens barrel,

wherein the lens position calculator determines, based on temperature information of the lens barrel output from the temperature sensor, a correction distance corresponding to a displacement from a reference temperature, and

the lens position calculator

designates a position obtained by performing addition or subtraction of the correction distance with respect to the judgment position as a new judgment position, and

designates the new judgment position as the position where the output value of the position detection sensor is detected for the judgment.

[29] The lens driving apparatus according to claim 17, further comprising a temperature sensor that detects a temperature of the lens barrel,

wherein the lens position controller controls a position of the imaging lens based on correction position information that is based on information of the reference position and temperature information of the lens barrel output from the temperature sensor.

[30] The lens driving apparatus according to claim 17, further comprising an angular sensor that detects an inclination angle of the lens barrel and a temperature sensor that detects a temperature of the lens barrel,

wherein the lens position calculator determines, based on inclination angle information of the lens barrel output from the angular sensor, an angle correction distance corresponding to a displacement from a reference angle, and determines, based on temperature information of the lens barrel output from the temperature sensor, a temperature correction distance corresponding to a displacement from a reference temperature, and

the lens position calculator

designates a position obtained by performing addition or subtraction of a total distance of the angle correction distance and the temperature correction distance with respect to the judgment position as a new judgment position, and

designates the new judgment position as the position where the output value of the position detection sensor is detected for the judgment.

[31] An imaging apparatus, in which a lens barrel and a camera main body are detachable,

wherein the lens barrel comprises:

an imaging lens group that includes a focus lens and forms an image of a subject;

a motor driver that includes a motor that shifts the focus lens in a direction of an optical axis;

a storage in which an information table containing control information of the focus lens is stored; and

a first data transmitter/receptor that transmits information output from the storage to the camera main body,

the camera main body comprises:

an imaging device that images light of the subject by way of the imaging lens group;

a second data transmitter/receptor that receives information transmitted from the first data transmitter/receptor; and

a motor controller that controls the motor in accordance with received information output from the second data transmitter/receptor,

wherein the focus lens is controlled in accordance with information that the motor controller transmits to the first data transmitter/receptor via the second data transmitter/receptor.

[32] The imaging apparatus according to claim 31,

wherein the motor driver outputs a periodic driving signal in accordance with received information output from the motor controller, and the motor shifts the focus lens in the direction of the optical axis in accordance with the output driving signal,

the lens barrel further comprises a position detection sensor whose output value varies with a position of the focus lens, and

the motor controller determines as a reference position of the focus lens a phase of the driving signal when an output value of the position detection sensor reaches a threshold value, and transfers information of the reference position via the second and the first data transmitter/receptor so as to allow the information of the reference position to be stored as information in the information table of the storage.

[33] The imaging apparatus according to claim 32,

wherein the motor controller

determines as a judgment position a position obtained by performing addition or subtraction with respect to the reference position read out from the storage via the first and the second data transmitter/receptor,

detects an output value of the position detection sensor via the first and the second data transmitter/receptor at a timing in synchronization with the driving signal that drives the motor driver and at the judgment position, and

judges whether the output value of the position detection sensor at

the judgment position reaches the threshold value or not, so as to determine the reference position again.

[34] The imaging apparatus according to claim 33, wherein the judgment position is located at a position 1/2 cycle of the driving signal away from the reference position read out from the storage.

[35] The imaging apparatus according to claim 31, wherein the information table comprises at least one of information on the number of magnetic poles of the motor, information on a rotation resolution of the motor, information on a driving voltage of the motor and information on a maximum driving rate of the motor.

[36] The imaging apparatus according to claim 31, further comprising a temperature sensor,

wherein the information table comprises correction information by a temperature on a position of the focus lens, and

the motor controller corrects the position of the focus lens in accordance with a temperature change based on temperature information of the temperature sensor and the correction information.

[37] The imaging apparatus according to claim 31, further comprising an angular sensor,

wherein the information table comprises correction information by an attitude angle on a position of the focus lens, and

the motor controller corrects the position of the focus lens in accordance with an angle change based on angle information of the angular sensor and the correction information.

[38] The imaging apparatus according to claim 31,

wherein the information table comprises information on operation cycle of the motor, and

the information on the operation cycle is updated in accordance with a movement distance or a movement time of the focus lens from turning on of a power supply of the imaging apparatus to completion of the power supply.

[39] The imaging apparatus according to claim 31, wherein the motor is at least one selected from the group consisting of a stepping motor, a linear motor, an ultrasound motor, a motor configured with a smooth impact driving mechanism, an electrostatic motor and a piezoelectric motor.

[40] The imaging apparatus according to claim 31, wherein parity is added to transmission/reception data between the first transmitter/receptor and the second transmitter/receptor.

[41] A lens barrel, comprising:

an imaging lens group that includes a focus lens and forms an image of a subject;

a motor driver that includes a motor that shifts the focus lens in a direction of an optical axis;

a storage in which an information table containing control information of the focus lens is stored; and

a first data transmitter/receptor that transmits information output from the storage to a camera main body,

wherein the lens barrel is used for the camera body comprising a motor controller that outputs information for controlling the focus lens via a second data transmitter/receptor, and

the focus lens is controlled in accordance with information that the motor controller transmits to the first data transmitter/receptor via the second data transmitter/receptor.

[42] The lens barrel according to claim 41, further comprising a position detection sensor whose output value varies with a position of the focus lens,

wherein the motor is driven by a periodic driving signal, and when the focus lens is shifted in the direction of the optical axis in accordance with the driving signal,

a phase of the driving signal when an output value of the position detection sensor reaches a threshold value is designated as a reference position of the focus lens, and information of the reference position is stored as information in the information table of the storage.

[43] The lens barrel according to claim 41, wherein the information table comprises at least one of information on the number of magnetic poles of the motor, information on a movement distance resolution of the motor, information on a driving voltage of the motor and information on a maximum driving rate of the motor.

[44] The lens barrel according to claim 41, wherein the information table comprises correction information by a temperature on a position of the focus lens.

[45] The lens barrel according to claim 41, wherein the information table comprises correction information by an attitude angle on a position of the focus lens.

[46] The lens barrel according to claim 41, wherein the information table can store information on operation cycle of the motor.

[47] The lens barrel according to claim 41, wherein the motor is at least one selected from the group consisting of a stepping motor, a linear motor, an

ultrasound motor, a motor configured with a smooth impact driving mechanism, an electrostatic motor and a piezoelectric motor.

[48] The lens barrel according to claim 41, wherein parity is added to transmission/reception data between the first transmitter/receptor and the second transmitter/receptor.

[49] A camera main body that is used for a lens barrel, the lens barrel comprising: an imaging lens group that includes a focus lens and forms an image of a subject; a motor driver that includes a motor that shifts the focus lens in a direction of an optical axis; a storage in which an information table containing control information of the focus lens is stored; and a first data transmitter/receptor that transmits information output from the storage to the camera main body,

wherein the camera main body comprises: an imaging device that images light of the subject by way of the imaging lens group; a second data transmitter/receptor that receives information transmitted from the first data transmitter/receptor; and a motor controller that controls the motor in accordance with received information output from the second data transmitter/receptor,

wherein the motor controller transmits information for controlling the focus lens to the first data transmitter/receptor via the second data transmitter/receptor.

[50] An imaging apparatus, comprising:

a lens barrel provided with a first lens unit and a second lens unit, each of which is movable in a direction of an optical axis;

a first driver that shifts the first lens unit in the direction of the optical axis;

a second driver that shifts the second lens unit in the direction of the

optical axis;

a controller that outputs a control signal to each of the first driver and the second driver; and

a position detector that detects a position of the second lens unit and also detects a position of the first lens unit by movement resulting from contact of the first lens unit with the second lens unit.

[51] The imaging apparatus according to claim 50, wherein the position detector comprises a member to be detected that moves together with the second lens unit in the direction of the optical axis and a sensor that detects a position of the member to be detected in the direction of the optical axis.

[52] The imaging apparatus according to claim 50, wherein the position of the first lens unit is detected by bringing the first lens unit into contact with the second lens unit by shifting the first lens unit by the first driver, followed by movement of the second lens unit together with the first lens unit, and by detecting a position of the member to be detected, which moves together with the movement, by means of the position detector.

[53] The imaging apparatus according to claim 50, wherein the position of the second lens unit is detected by shifting the first lens unit together with the second lens unit by the first driver, followed by shifting of the second lens unit by the second driver, and by detecting a position of the member to be detected, which moves together with the shifting of the second lens unit, by means of the position detector.

[54] The imaging apparatus according to claim 50,

wherein the second lens unit is moveable along a supporting member in the direction of the optical axis,

shifting of the second lens unit by the second driver is performed by

way of a movement restriction unit that is shifted by the second driver,

shifting of the second lens unit by the first driver is performed by way of a movement conveying unit that moves to be linked with the first lens unit, and

the movement restriction unit and the movement conveying unit both are disposed closer to the supporting member.

[55] The imaging apparatus according to claim 51,

wherein the position detector is a light-transmission type sensor, and

the member to be detected is a photo-interruption member of the light-transmission type sensor.

[56] The imaging apparatus according to claim 50,

wherein the first lens unit is a zoom lens unit, and

the second lens unit is a focus lens unit.

[57] An imaging apparatus, comprising:

a power supply;

a lens barrel provided with a first lens unit and a second lens unit, each of which is movable in a direction of an optical axis;

a first driver that shifts the first lens unit in the direction of the optical axis;

a second driver that shifts the second lens unit in the direction of the optical axis;

a controller, when electric power is supplied from the power supply or when the power supply is shut off, making the first driver shift the first lens unit so as to perform predetermined process operations for supplying the electric power or shutting off the power supply; and

a storage that stores information different between a normal completion state and an abnormal completion state, in which in the normal

completion state, the first lens unit and the second lens unit are shifted to storage positions in accordance with a predetermined process operation when the power supply is shut off from a state of the supplying the electric power, and in the abnormal completion state, the apparatus to which electric power is being supplied is completed in a state different from the normal completion state,

wherein when electric power is supplied after the abnormal completion state, the first lens unit and the second lens unit are returned to the normal completion state in accordance with the information stored in the storage.

[58] The imaging apparatus according to claim 57, wherein when electric power is supplied after the abnormal completion state, the first lens unit and the second lens unit are returned to the normal completion state in accordance with the information stored in the storage, and the first lens unit is shifted at least by the first driver so as to perform the predetermined process operation for supplying the electric power.

[59] The imaging apparatus according to claim 57, wherein the storage is a nonvolatile memory or a volatile memory driven by a secondary power supply.

[60] The imaging apparatus according to claim 57,
wherein the first lens unit is a zoom lens unit, and
the second lens unit is a focus lens unit.

[61] A driving apparatus that drives a body to be driven, comprising:
a restriction end that restricts movement of the body to be driven;
a stepping motor that drives the body to be driven by rotation of a rotor resulting from a change in exciting position in accordance with a

pattern of an exciting current;

a driver that supplies the exciting current to the stepping motor;

an origin storage unit that stores an exciting position corresponding to an origin of the body to be driven beforehand;

a counting unit that counts the exciting position varying with the pattern of the exciting current supplied by the driver and an absolute position of the body to be driven corresponding to the exciting position; and

a calculation unit that resets the origin,

wherein at the exciting position stored in the origin storage unit, the rotor receives a magnetic force in such a manner that the body to be driven is separated from the restriction end after the exciting position is advanced so that the body to be driven is closer to the restriction end and when the exciting position is advanced further from a state where movement of the body to be driven is restricted by the restriction end.

[62] The driving apparatus,

wherein the calculation unit resets the origin by

reading out the exciting position stored in the origin storage unit,

making the driver drive the stepping motor so as to advance the exciting position so that the body to be driven is brought closer to the restriction end, and advance the exciting position from a state where the movement of the body to be driven is restricted by the restriction end to the position corresponding to the read out exciting position, and

resetting a value of the absolute position corresponding to this exciting position.

[63] The driving apparatus according to claim 61,

wherein the number of patterns of the exciting current supplied to the stepping motor is n+1 from 0 to n (n+1 is an even number of 4 or more),

as the number of the patterns of the exciting current is advanced

from 0 to n, the body to be driven approaches the restriction end,

assuming that when restriction of movement of the body to be driven is started, the number of the pattern of the exciting current is n, and the exciting positions have the number of 0 to n corresponding to the respective numbers of the patterns of the exciting current,

the number of the exciting position corresponding to the origin is within a range from (n+1)/2 to n–1.

[64] The driving apparatus according to claim 61, further comprising an offset storage unit that stores an offset movement amount corresponding to a movement amount from the exciting position stored in the origin storage unit to a specific position that is a predetermined distance away from the exiting position stored in the origin storage unit,

wherein the calculation unit controls, after resetting the origin of the body to be driven, the driver so as to make the body to be driven move by the offset movement amount stored in the offset storage unit.

[65] The driving apparatus according to claim 61, wherein the body to be driven is a stop that controls a light amount of a subject light.

[66] A lens driving apparatus comprising the driving apparatus according to claim 61, wherein the body to be driven is a lens supporting frame that supports a lens element.

[67] The lens driving apparatus according to claim 66, wherein the body to be driven is the lens supporting frame and a stop that controls a light amount of a subject light.